THE EFFECT OF

Retempering Cement Mortars,

BY

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THESIS

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INTRODUCTION.

Although masonry specifications generally state that cement mortar shall be used immediately after mixing, it is highly probably that it is sometimes retempered (i.e. remixed after it has partially set.)

The object of the experiments here described was to determine the effect of this retempering upon the tensile strength. apparently the first experiments to determine this effect were those made by L.H.Goddard and P.P.Evans, class of 1892 of Ohio State University, for their thesis, which was published in the Engineering News, January 5, 1893.

Goddard and Evans retempered their cements for eigth hours regardless of the activity of the cement. The use of a uniform time of retempering is objectionable for the following reasons: First, the time must be arbitrarily choosen. If it is short the slow setting cements will scarcely more than attain their initial set; and, on the other hand, if the time is long the quick setting cements must be re-mixed more frequently than the slow setting ones. Second, a uniform time of retempering does not thoroughly represent the conditions of actual practice; for it is difficult to conceive of a mason who would, either accidently or intentionally, retemper a quick setting Rosendale as long as he would a slow

setting Portland. Third, the data obtained for a uniform time of retempering connot be used to make comparisons between the quick and the slow setting cements.

Therefore we adopted a time of retempering which was proportional to the activity of the cement.

THE CEMENT.

In our experiments, we used one brand of Portland cement and three of Rosendale. Each cement was tested for activity, fineness, and soundness. For details of the place of manufacture, fineness, etc.,of each cement, see table 1, page 8 .

TEST FOR ACTIVITY. The test for activity recommended by General Gillmore was used. A pat of the mortar was placed on a piece of glass and allowed to set in the air. A note was made of the interval elapsing from the time of adding the water until the mortar would just support a wire 1/12 inch in diameter weighing 1/4 pound and also the interval elapsing from the time of adding the water until the mortar would just support a wire 1/24 inch in diameter weighing one pound. For the result of this test, see table1, page

TEST FOR FINENESS. Thecement was tested forfineness by passing it through three sieves, number 50, 80 and 100, and noting the per cent passing each.

Number 50 sieve contains 2500 meshes per square inch.

" 80 " " 6400 " " " "

" 100 " " 10000 " " " "

For result of this test see table 1, page 8 .

TEST FOR SOUNDNESS. The cement was tested for soundness by placing a pat of the mortar with thin edges in water for seven days and noting whether cracks appear on the edges of the pat. No cracks appeared, and hence we concluded that all the cements were sound.

THE MORTAR.

METHOD OF MIXING AND RETEMPERING. A quantity of cement sufficient to make twelve briquettes was mixed on a slate table with enough water to make a plastic mortar. Twenty-six per cent of water was used for the Portland cement, thirty-three per cent for the Louisville and Utica cements, and thirty-six per cent for the Milwaukee cement. Six briquettes were molded immediately after mixing the mortar, and the remainder of the mortar was allowed to set until it would support a wire 1/12 inch in diameter weighing 1/4 pound. The mortar was then re-mixed and enough water was added to make it of the same consistency as at the first mixing. The mortar was then again put aside and allowed to set until it would support the same wire, and was then re-mixed as before and placed in the molds.

METHOD OF MOLDING. The briquettes were molded in brass molds on a slate table. The mortar was pressed into the molds with the fingers, care being taken to pack it uniformaly. The briquettes were covered with wet cloths and left in the molds about twenty hours.

METHOD OF STORING. After being taken from the molds, the briquettes were placed in pans filled with water and allowed to stand until broken.

MANNER OF BREAKING. The briquettes were broken on a Riehle cement testing machine. The strain was applied at the rate of four hundred pounds per minute for the Portland cement and at two hundred pounds per minute for the Rosendale cement. Grips with rubber on the jaws were used. Sixty-one per cent of the briquettes broke at the smallest cross section.

THE DATA.

Table 2, page , gives the tensile strength of the tempered and retempered cements at seven, twenty-eight, fifty-six and eighty-four days. Plates 1, 2, 3, and 4, pages 10 to 13, show the effect on the tensile strength of retempering the several cements. Plate 5 shows the per cent of loss or gain in tensile strength by retempering. Plate 6 shows the comparative tensile strength of the cements tempered and retempered.

As before stated the cements were retempered after they would support a wire 1/12 inch in diameter and weighing 1/4 pound. They were retempered twice before being put into the molds. A reference to column five of table 3, page 9 , shows that the times of retempering the several batches of any particular cement, especially the Rosendales, differ considerably.

This is probably due to a great extent at least, to the differ-

ence of temperature in the room while the retempering was in prog -ress. During the retempering of the mortar for the briquettes broken at the end of seven days, the temperature on the room was about 65° F.

The abnormal low value for the strength of the Portland re-tempered mortar at fifty-six days (see table 2, page 9 , or plate 1, page 10) is probably due to the mortars freezing at night while it was retempering.

CONCLUSIONS.

The Portland cement at the end of seven days lost twenty-three per cent of its tensile strength by retempering; but for twenty-eight, fifty-six and eighty-four days there was no loss by retem-pering. Hence the only effect of retempering Portland cement is to retard its setting which effect has entirely disappeared at the end of twenty-eight days.

The Milwaukee cement at the end of seven days lost ninety per cent of its tensile srtength by retempering; but for twenty-eight, fifty-six and eighty-four days the cement had gained six, twelve and thirteen per cent respectively by retempering. Hence retemper-ing Milwaukee cement has a very injurious effect on the tensile strength of the mortar at the end of seven days, which seems to be caused by retarding the setting of the cement. For twenty-eight days and longer retempering seems to imcrease the strength of the cement.

The Louisville cement losses activity by retempering and is greatly waekened for a short time, but gradually acquires strength until it reaches about seventy-five to eighty-five per cent of the strength of the mortar when not retempered.

The Utica cement is effected in much the same way as the Louis -ville and for which the same conclusions maybe drawn.

THE EFFECT OF ACTIVITY AND FINENESS ON RETEMPERING is shown in plate 7, which was made from data in tables 1 and 2.

The first eight diagrams show the relation of activity to the ability of the cement to stand retempering. The left hand column of each diagram gives the initials of the cement in the order of their activity. The column on the right of each diagram gives the initial of the cements in the order of their ability to stand retem- pering. From these diagrams the conclusion is drawn that there is no law connecting the activity of a cement and its ability to stand retempering.

The last four diagrams of plate 7 show the relation of fineness to the ability of the cement to stand retempering. The left hand column of each diagram gives the initial of the cements in their order of fineness. The column to the right gives the initials of the cements in order of their ability to stand retempering. From these diagrams the conclusion is drawn that there is no law con- necting the fineness of a cement and its ability tostand retemp -ering.

IN GENERAL while the retempering of cement mortar cannot be commended, since no advantage is gained thereby, unles perhaps the retempering mortars work a little better, the preceeding conclusions show that if retempered mortar is used, either by accident or for economy'e sake, no very seriour damage will occur if the full strength of the masonry is not required too soon. However, before adopting these conclusions as final, the experiments should be repeated under new conditions and perhaps further exten-ded. These experiments are the more necessary since our results are contrary to the general beleif as to the effect of retempering cement mortar. Farther as the different cements seem to be very differently effected by retempering, the new experiments should include still other brands.

TABLE I. RESULTS OF TEST OF CEMENTS.

DESCRIPTION OF CEMENTS		TEST FOR FINENESS PER CENT LEFT ON SIEVE			TEST FOR ACTIVITY		
KIND	PLACE OF MANUFACTURED	No. 50.	No. 80	No. 100.	a*	b*	c*
PORTLAND	GERMANY	2.2	8.0	13.0	$7^{H.}\ 30^{M}$	$6^{H.}\ 45^{M}$	$14^{H.}\ 15^{M}$
ROSENDALE	MILWAUKEE, WIS.	5.0	14.0	19.4	2 30	2 25	4 55
" "	UTICA, ILL.	13.5	30.5	35.4	1 10	0 55	2 05
" "	LOUISVILLE, KY.	16.5	24.4	28.0	$1^{H.}\ 15^{M}$	$0^{H.}\ 30^{M}$	$1^{H.}\ 40^{M}$

* a = Interval from time of adding water until light wire was borne.
b = " " " light wire was borne until heavy " " " .
c = " " " of adding water " " " " " " .

TABLE II. RESULTS OF TENSILE TEST OF BRIQUETTES.

KIND OF CEMENT.	AGE IN DAYS.	RETEMPERED							NOT RETEMPERED.					PER CENT OF GAIN OR LOSS	
		TOTAL NUMBER BROKEN.	% BREAKING IN NECK.	INTERVAL FROM TIME WATER WAS ADDED UNTIL MORTAR WAS MOLDED.		TENSILE STRENGHT IN POUNDS PER SQUARE INCH			TOTAL NUMBER BROKEN.	% BREAKING IN NECK.	TENSILE STRENGHT IN POUNDS PER SQUARE INCH				
						MIN.	MAX.	MEAN			MIN.	MAX.	MEAN	GAIN	LOSS
PORTLAND.	7	6	66	14 H.	15 M.	280	330	309	5	50	360	440	400		23
	28	6	50	20	00	490	548	521	4	40	492	538	512	2	
	56	6	66	20	00	364	460	404	6	83	600	730	672		40
	84	6	66	19	00	590	722	685	3	66	602	726	679	0.9	
MILWAUKEE	7	5		4	55	0	7	4	6	83	32	42	36		90
	28	6	33	7	20	90	120	102	6	50	90	96	112	6	
	56	4	33	4	55	102	132	115	5	50	100	106	102	12	
	84	5	60	3	28	134	174	156	5	60	128	150	138	13	
UTICA	7	5	80	2	10	16	30	26	6	50	41	44	42		38
	28	6	66	5	20	112	138	124	6	83	174	198	189		34
	56	5	80	3	40	140	172	158	6	66	234	256	246		36
	84	5	80	4	05	226	241	236	6	50	268	308	289		19
LOUISVILLE	7	6	50	1	40	23	40	34	6	50	92	110	101		66
	28	6	50	2	45	54	77	67	6	83	117	146	128		48
	56	6	66	1	45	128	146	138	6	83	134	180	160		14
	84	6	50	2	30	120	162	140	6	66	164	202	179		22

PLATE I

PORTLAND CEMENT.

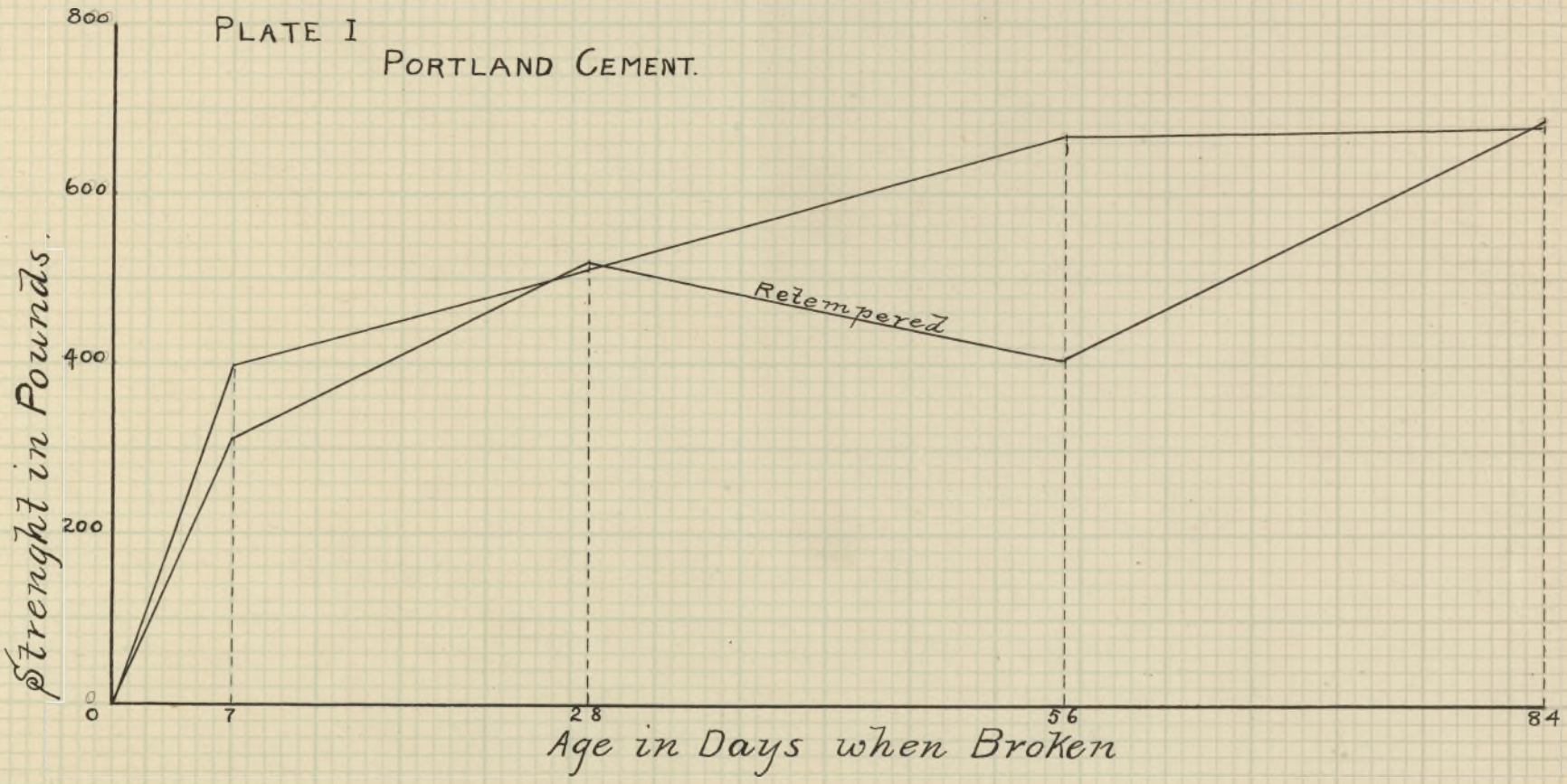


PLATE II

UTICA CEMENT

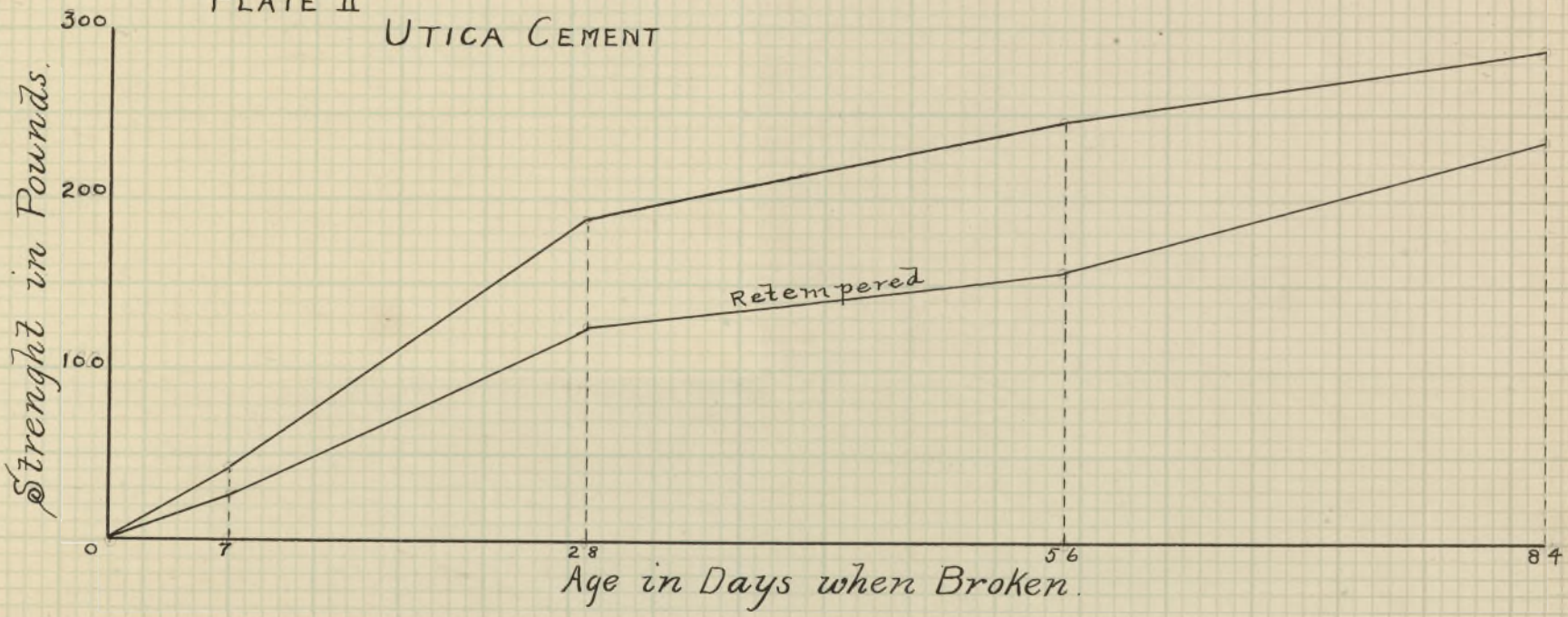


PLATE III

LOUISVILLE CEMENT.

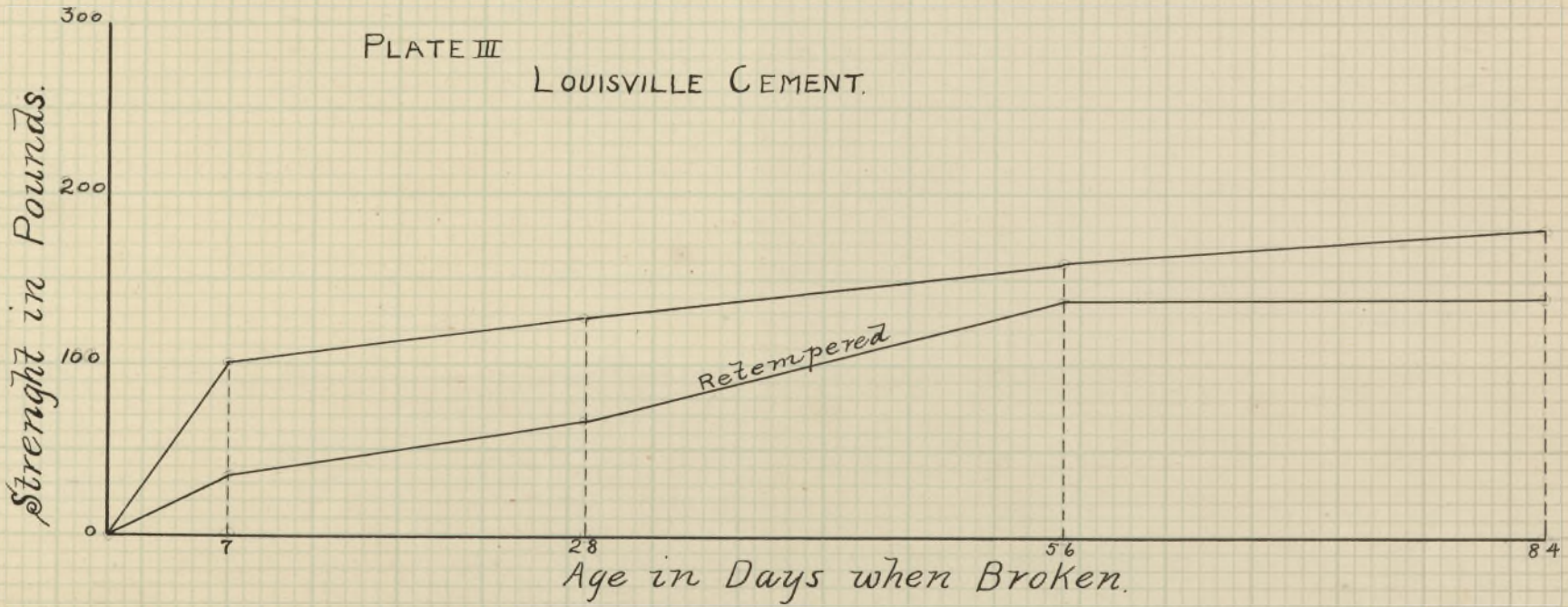


PLATE IV.

MILWAUKEE CEMENT

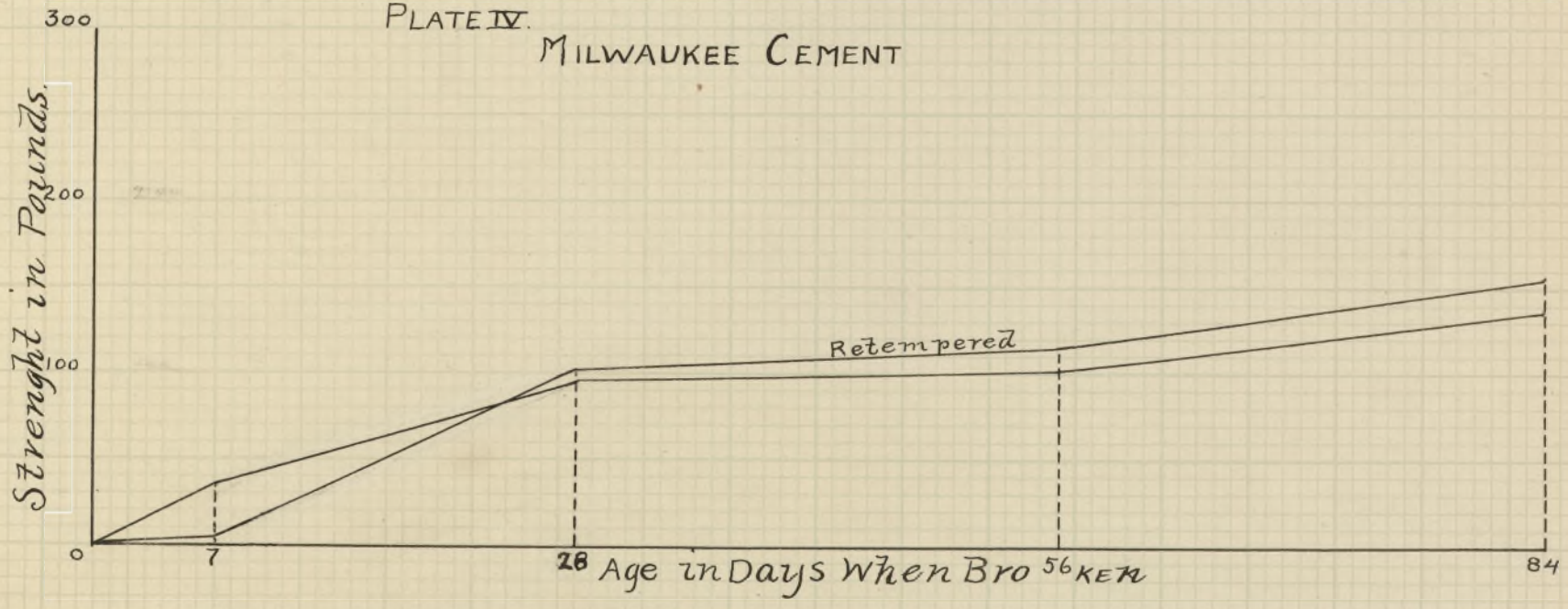


PLATE V

Showing the Loss or Gain by Retempering in Per Cent.

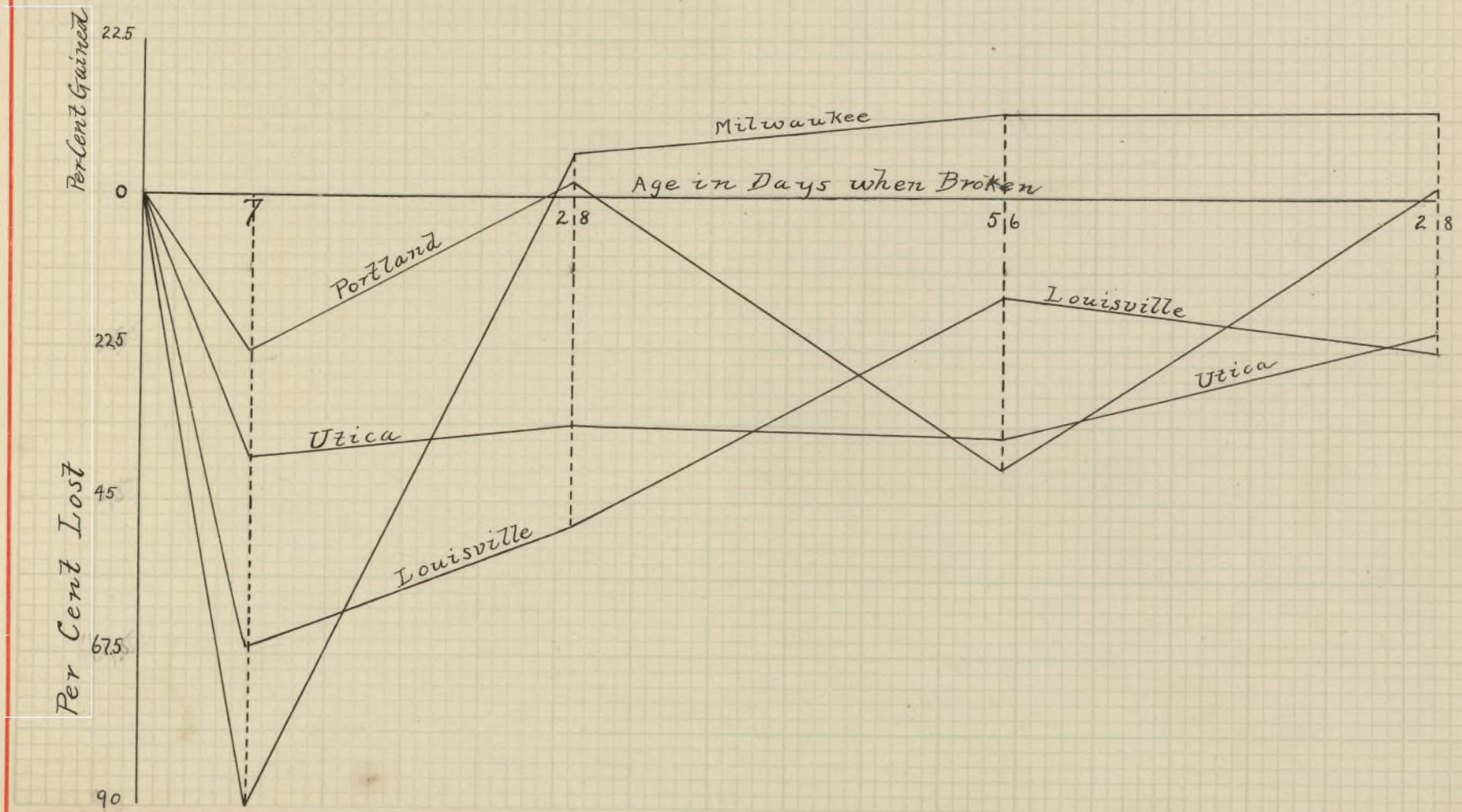


PLATE VI

Showing Comparative Strenght of the four Cements Retempered and not Retempered.

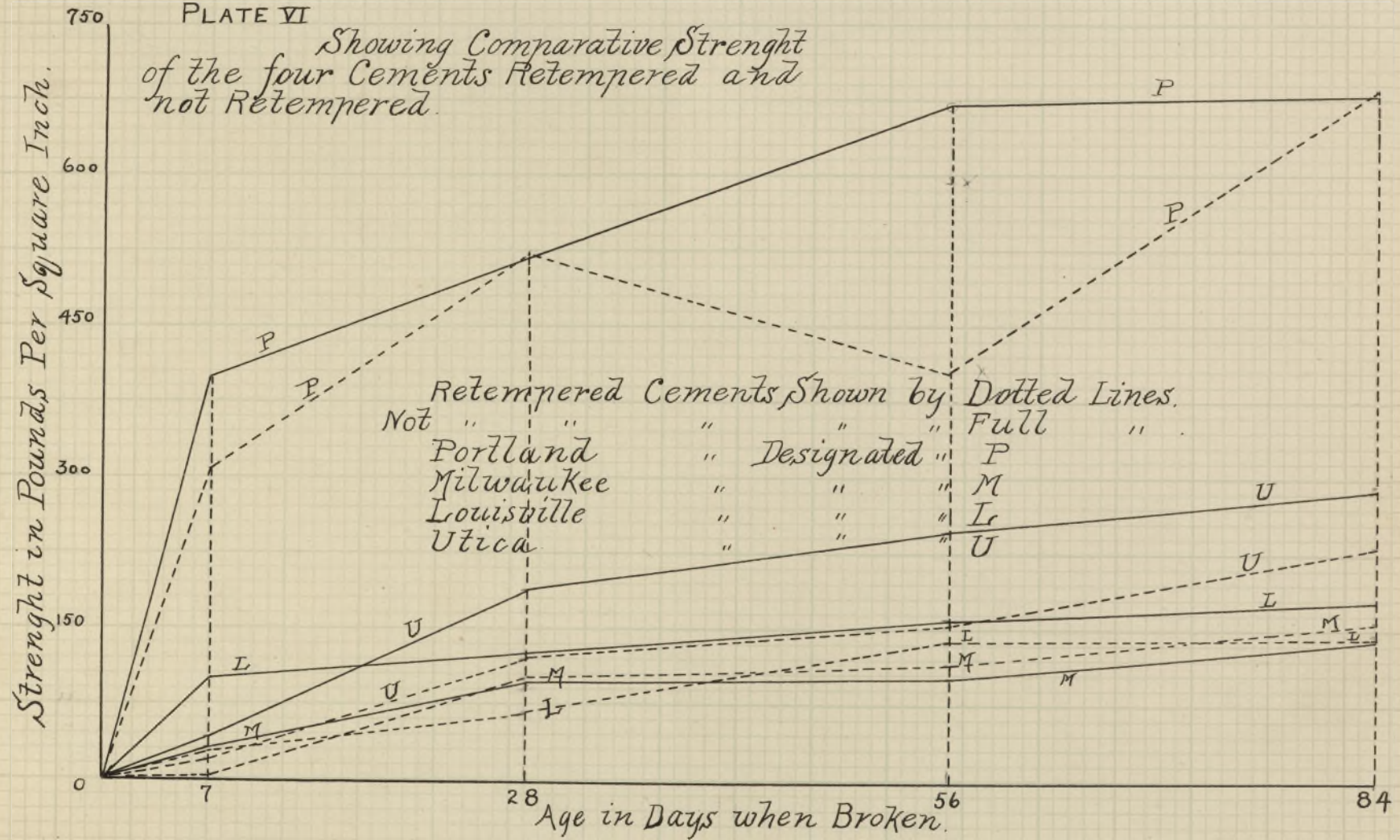
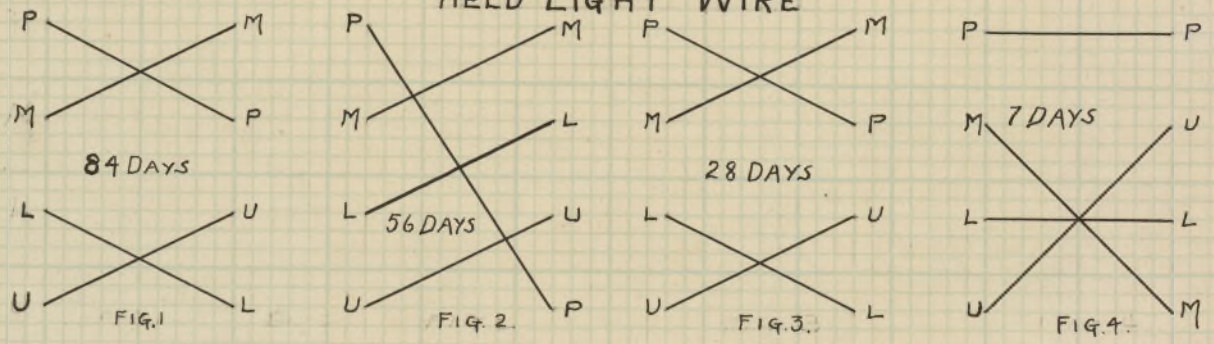


PLATE VII

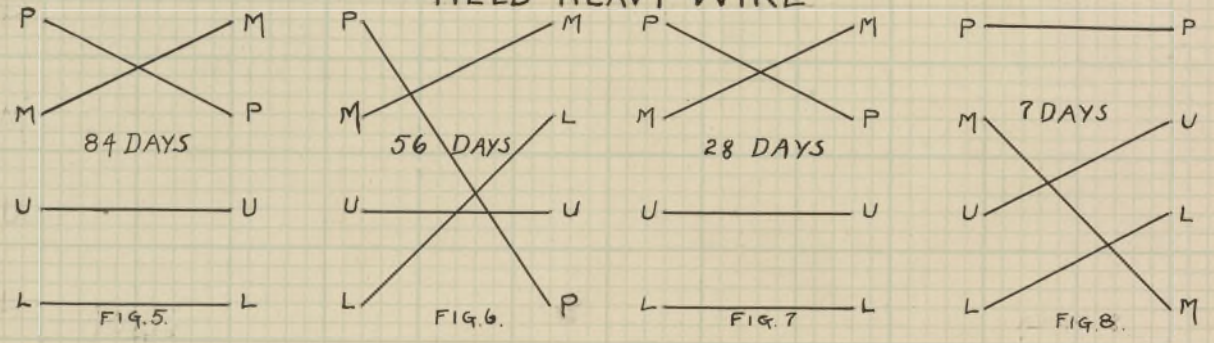
DIAGRAM SHOWING RELATION OF ACTIVITY AND FINENESS TO THE ABILITY OF THE CEMENT TO STAND RETEMPERING.

ACTIVITY

HELD LIGHT WIRE



HELD HEAVY WIRE



FINENESS